3. The results of our experiments show that: (*a*) The normal heart responds to any exercise within its power by a diminution in size; (*b*) About one-half of the pathological hearts, which are in good compensation, respond to exercise within their power, with a diminution in size; (*c*) Approximately one-half of the pathological hearts, with manifest, but low-grade broken compensation, respond in the same manner by some degree of diminution in size.

4. In only the most exceptional instances, if ever, are the differences in size due to acute dilatation, sufficient to be determined by even the most refined and subtle percussion.

5. The Roentgen-ray examination of the heart, before and after appropriate exercise, using the technique employed in this research, is capable of rendering valuable assistance in the estimation of the functional efficiency of the heart.

My sincere thanks are due to Dr. Adolph Hartung, instructor in roentgenology, College of Medicine, University of Illinois, for his generous assistance. The negatives of all the cases were made by Dr. Hartung, and to his skill and coöperation much credit is due.

My thanks are also due to Dr. Ernest S. Moore and Dr. Robert Mosser, instructors in the medical clinic, for assistance in the selection and observation of the cases.

DILATATION OF THE ARCH OF THE AORTA IN CHRONIC NEPHRITIS WITH HYPERTENSION.

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This report is based on Roentgen-ray plates taken in the routine of clinical work at the Massachusetts General Hospital during the last eighteen months by Dr. Walter J. Dodd and Dr. George W. Holmes, to whom we are indebted for permission to use the records of the department. All the plates were taken at a distance of seven feet, that is, with practically parallel rays, thus allowing for quite accurate measurements of the shadows of the heart and great vessels.

With a series of about sixty normal plates available it is not practical to lay down accurate normal limits for the measurements of the transverse diameter of the great vessels, since many of the plates are slightly distorted on account of not being taken accurately in the frontal plane, etc. The limits of 4.5 and 5.5 cm., however, include by far the largest number of normal measurements (see curve *a*, Fig. 1, of normals). It is fair to state that in no case did the great vessels measure more than 6 cm. in diameter in which there was not evidence of one of the following:

1. Syphilis (*i. e.*, aortitis).
2. Age over fifty years (*i. e.*, probable factor of arteriosclerosis).

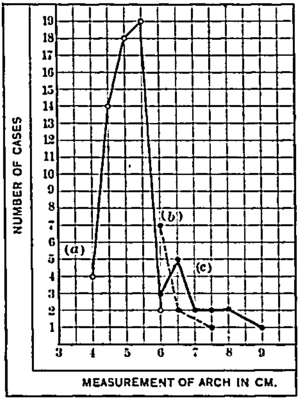

FIG. 1.—To show graphically the limits of arch diameters found in the conditions studied, obtained by plotting the number of cases found at each diameter and including all the cases which had had plates taken at seven feet without selection. *a*, ○——○——○ normal; *b*, ●---●---● cardiac disease with enlargement but without hypertension or syphilis; *c*, ●——●——● chronic nephritis with hypertension.

3. Other serious cardiac disease (*e. g.*, endocarditis or pericarditis with cardiac enlargement).
4. Hypertension (with more or less hypertrophy, *e. g.*, in chronic nephritis).

Therefore, great vessels measuring more than 6 cm. in diameter may usually be considered as dilated.

In this series, cases in which an increase in the diameter of the great vessels could be explained by either (1) syphilis or (2) arteriosclerosis of age have been ruled out, but it is striking to note how many cases of dilated arch remain to be classified under (3) cardiac disease with enlargement and (4) hypertension.

A. Dilatation of the Arch with Other Cardiac Disease.[1] There were ten cases with arches at the upper limit of normal or above (see curve *b*, Fig. 1), in which neither age, syphilis, nor hypertension could be found to explain the dilatation. (As an approximate index of the degree of cardiac enlargement the total transverse diameter of the heart is also given in Table I, *i. e.*, the distance of the right border from the median line plus the distance of the left border from the median line. The maximum normal total transverse diameter of the adult heart is given as 13.2 cm.[2]).

Table I.—Cases of Dilatation of Arch Associated with Other Cardiac Disorders.

Case.	Age.	Diameter of arch.	Total transverse diameter of heart.	Blood-pressure.	Diagnosis.
		Cm.	Cm.		
1	36	6.0	14.0	110	Chronic mitral endocarditis.
2	41	6.0	18.0	110	Chronic mitral endocarditis.
3	28	6.0	15.0	100	Chronic mitral endocarditis.
4	18	6.0	14.0	140	Chronic aortic endocarditis.
5	40	6.0	14.5	120	Hyperthyroidism with hypertrophy.
6	27	6.0	15.0	110	Chronic aortic and mitral endocarditis.
7	24	6.0	12.0	130	Chronic aortic and mitral endocarditis.
8	25	6.5	18.5	120	Chronic aortic and mitral endocarditis.
9	33	6.5	19.0	110	Pericarditis.
10	43	7.5	15.5	100	Adherent pericardium.

All of these cases, therefore, had some other definite cardiac lesion, and most of them had considerable increase in the heart size. Whether the measurements of the Roentgenograms represent the actual degree of dilatation of the arch, or whether some of the increase in diameter may be explained by distortion brought about by the cardiac enlargement, is a question which must be settled by autopsies, by Roentgen rays taken in several planes, etc. The point brought out is that many cases of cardiac disease without syphilis or hypertension show by Roentgen rays, great vessels whose diameter is at the upper limit of normal (6 cm.) or above.

B. Dilatation of the Arch with Hypertension. There were fourteen cases of chronic nephritis in which chest plates had been taken at a distance of seven feet. The blood-pressures ranged from 185 (one case) to 270, taking in each case the highest blood-pressure recorded while in the hospital. The average was 215. The ages were from 29 to 54, averaging 43. The transverse diameters of the hearts varied from 13.5 (one case) to 19 cm., averaging 16 cm. (normal maximum 13.2 cm.).

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[1] A well-recognized condition; see McCrae, Dilatation of the Aorta, Amer. Jour. Med. Sci., 1910, cxl, 469.

[2] Groedel, Die Rontgendiagnostik der Herz- und Gefässerkrankungen, Berlin, 1912.

All but three of these cases had great vessels whose transverse diameters measured over the normal limit of 6 cm., and in one of those measuring 6 cm. the Roentgen-ray diagnosis was "slight dilatation of the arch." In two cases the diameter was 7 cm.; in two cases 7.5 cm.; in two cases 8 cm.; and in one case 9 cm. (See curve *c*, Fig. 1, cases of chronic nephritis.)

TABLE II.—Cases Showing Dilatation of Arch with Chronic Nephritis and Hypertension.

Case.	Blood-pressure.	Diameter of arch.	Transverse diameter of heart.	Age.	Wassermann.
		Cm.	Cm.		
1	240	6.0	16.5	53	Negative.
2	190	6.0	16.5	38	Negative.
3	200	6.0	14.5	49	Negative.
4	230	6.5	14.0	54	Not done.
5	190	6.5	16.0	38	Negative.
6	270	6.5	17.5	45	Negative.
7	200	6.5	15.5	42	Negative.
8	220	7.0	13.5	35	Negative.
9	220	7.0	15.0	35	Negative.
10	185	7.5	18.0	29	Negative.
11	220	7.5	15.0	43	Negative.
12	190	8.0	19.0	43	Negative.
13	250	8.0	14.0	50	Negative.
14	220	9.0	18.5	48	Negative.

In the production of the varying degrees of dilatation of the arch in chronic nephritis four factors must be considered:

1. *Cardiac Hypertrophy*, since it has been shown above (see curve *b*) that (apparent) dilatation of the arch occurs in association with simple cardiac enlargement without hypertension. The diameter of the heart in each case has been plotted as a curve (*d*, Fig. 2), which shows a general but by no means constant increase of the size of the heart with the size of the arch. It will be noted, however, that the degree of dilatation occurring in chronic nephritis is much more than that found associated with simple hypertrophy (curve *c*), so that another factor must evidently be found.

2. *Hypertension* is an obvious factor. The degree of hypertension in each case when plotted as a curve, however (curve *c*, Fig. 2), does not show the greatest hypertensions to be associated constantly with the greatest degrees of dilatation.

3. *Duration of the Hypertension* is undoubtedly an important factor. Chronic nephritis, however, being a disease of notoriously insidious onset, it is almost impossible to determine accurately the duration of any given case from a hospital record, and it was found in this series that no constant relation could be demonstrated between the apparent duration and the size of the arch or

the size of the heart. It is probable that the degree of dilatation of the arch is related to all three factors: the degree and the duration of hypertension and to a small extent associated with the simple cardiac enlargement.

4. *Age.* It was found that the average age of the cases of chronic nephritis with arches measuring from 6 to 7 cm. was 45.5, while the average age of those measuring from 7 to 9 cm. was 40.4. This is contrary to what would be naturally expected, since dilatation of the arch is common, associated solely with the arteriosclerosis of age. It has been suggested as a tentative explanation that when hypertension supervenes on an aorta already somewhat stiffened from age it does not stretch as easily as does a young one.

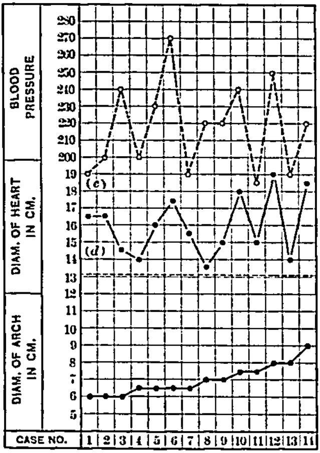

Fig. 2.—Blood-pressure and size of heart in each case of chronic nephritis, arranged in order of increasing diameters of arches. *d*, ●——●——● diameter of heart; *c*, ○---○---○ blood-pressure.

Conclusions. The point of interest brought out by these cases is the frequency of dilatation of the arch under the age of fifty years in non-syphilitic conditions, especially in chronic nephritis with hypertension. In such cases there were no aortas below the upper limit of normal diameter (6 cm.); three aortas at the upper limit of normal; and eleven aortas definitely dilated. This dilatation may be quite marked—especially in the younger patients—in seven, or 50 per cent., of these cases the diameter measured from 7 to 9 cm., or 1 to 3 cm. above normal.